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13. ABSTRACT (Maximum 200 words) At high latitudes, data sets were used from a large number of stations of the International GPS Service for Geodynamics. In Europe - Ny Alesund, Tromso, Kiruna and Onsala. In North America - Yellowknife, Fairbanks, Algonquit, St. John's. These data sets were used to determine if one could forecast when scintillations would be present during magnetically quiet periods and during storm periods. It was found in a study of the magnetic storm of November 3-4, 1993 that both intensity and occurrence of the irregularities increased at the auroral site of Yellowknife during the storm. Later in the storm the lower latitude station of Algonquin developed irregularities as the irregularity oval expanded. Other storms will be studied to determine the rate of expansion of the irregularity oval.				
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February 14, 1996

Enclosed ^{are 4 copies} ~~is a copy~~ of the quarterly report for the
period ending December 31, 1995 on ONR Grant
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Sincerely

A handwritten signature in cursive script, appearing to read 'Jules Aarons', is written over the printed name.

Jules Aarons
Research Professor

ENCL (4)

OFFICE OF NAVAL RESEARCH

QUARTERLY REPORT

for

1 October 1995 - 31 December 1995

GRANT No.: N00014-89-J-1754

**THE EFFECTS OF MAGNETIC STORM PHASES ON
F-LAYER IRREGULARITIES
FROM AURORAL TO EQUATORIAL LATITUDES**

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A. HIGH LATITUDE PHASE FLUCTUATION AND SCINTILLATION STUDIES

In this quarter, this grant's studies concentrated on the high latitudes while a second grant (the PRIMER grant for the Northeast Consortium) took up equatorial studies.

In order to understand the present series of studies for ONR, we repeat the previously printed background of our use of GPS data.

F layer irregularity studies stem from the scientific community's interest in the physics of plasma instabilities and from the technical interest in the effects of the ionosphere on radio signals. A relatively new data source has been available for these studies, the observations of the International GPS Service for Geodynamics (IGS). To explore this resource a program of studies of phase fluctuations and total electron content (TEC) has been developed at the Center for Space Physics of Boston University.

Phase fluctuations in the present study of Boston University are obtained by examining Total Electron Content variations. Thirty second values of phase differences between the 1.2 GHz and the 1.6 GHz signals of each GPS satellite were recorded. The rate of change of the 30 second values is the source of the phase fluctuation study. With the data set consisting of 30 second samples, thus limiting spectral characteristics, we have chosen to call our data "phase fluctuations". The use of these relatively long samples means that we are studying irregularity structures of the order of several kilometers. It should be noted that amplitude scintillations result from scattering from irregularities of the order of several hundred meters to a kilometer. Jicamarca radar backscatter returns result from probing 3 meter irregularities. From the cascading properties of the development of irregularities, it is expected that the general morphology of the phase fluctuations will follow that of amplitude scintillation data.

One minute dTEC/dt values were obtained from the GPS 30 second TEC data. The analysis then followed several paths. Very large scale changes of irregularities are eliminated. In addition TEC values were computed only where the elevation of the satellite is greater than 5 degrees. This was done in order to avoid problems of tropospheric fluctuations on the signal as well as to minimize the effects of physical obstacles in the propagation paths.

DATA SETS

At high latitudes data sets were made for the following stations of the IGS.

In Europe: Ny Alesund, Tromso, Kiruna, Onsala

In North America: Yellowknife, Fairbanks, Algonquin, St. Johns

In addition data were taken for some storms from McMurdo Sound at Thule at 85° CGL for these measurements with coverage 82° to 88°. The data sets were all taken during sunspot minimum levels in 1993-1995.

At equatorial latitudes the data sets included those from the following stations.

Arequipa, Peru Santiago, Chile Kourou, Guyana Fortaleza, Brazil

AT HIGH LATITUDES, THE DEVELOPMENT OF IRREGULARITIES PROCEEDS EQUATORWARD AS THE MAGNETIC STORM DEVELOPS

NOVEMBER 3-4, 1993 MAGNETIC STORM PERIOD

One example of the type of study being made was done for the great magnetic storm of November 3-4, 1993. The high latitude station of Yellowknife, Canada (69.5° CGL) frequently shows phase fluctuations near local midnight even during quiet magnetic conditions; these were seen in the data for November 2nd and 3rd. However after the commencement of the magnetic storm near 00 UT on November 4, the intensity of the fluctuations increased and the areas affected by the development of irregularities moved equatorwards. In order to develop phase fluctuations of the order of .5 Total Electron Content Units/ minute at 1.2 and 1.6 GHz, irregularity intensity must be relatively high compared to phase scintillations at lower frequencies; thus scintillations at 250 MHz (AFSATCOM and FLTSATCOM) will show greater intensity during the same periods as those noted in GPS observations.

A second study at high latitudes has shown that there is a poleward movement of the irregularity region during extended magnetic quiet. In fact in years of solar minimum and with many days of low magnetic indices, the irregularities may cease to exist for the UHF frequencies. As has been shown (Aarons et al, 1995) the irregularity region does not follow the latitudinal movements of the auroral oval. We have analyzed two examples of the poleward movement of the irregularity region from auroral latitudes to either extremely high latitudes or to a very low irregularity intensity level. These occurred in 1994 and 1995 during solar minimum. The analysis of one period was shown in data prepared for the Spring AGU Meeting; the second will be included in a paper on high latitude irregularities in preparation.

Observations are available for all latitudes from the international group of GPS stations. The focus of this study is turning to the correlation of scintillation activity at high latitudes and the development during the same periods of phase scintillation in the equatorial region. at the equator.

B. APPLETON LECTURE OF THE UK INSTITUTE OF ELECTRICAL ENGINEERS AWARDED TO J. AARONS

Once a year the United Kingdom's Institute of Electrical Engineers selects a member of the radio wave propagation community to be the Appleton Lecturer. In 1995 Professor Jules Aarons was chosen to deliver the lecture. On January 11th, 1996 he gave the lecture, summing up the impact of scintillation research on systems proposed and in operation.

C. PRESENTATION AND PUBLICATION

June, 1995

Presentation and publication of "50 Years of Ionospheric Scintillation" by J. Aarons in London at the Institute of Electrical Engineers; published by IEE in "100 Years of Radio".

June, 1995

Presentation and Future Publication of "Communications and the Global Positioning System"

by J. Aarons, M. Mendillo, and R. Yantosca. AGARD Symposium Athens, Greece

D. THE ONR AASERT PROGRAM IN UPPER ATMOSPHERE AND IONOSPHERIC PHYSICS

Over the past quarter, Ms. Colerico has upgraded the Goose Bay imaging system including a new detector for the camera and a new optical storage drive. She continues to remotely monitor its operation from Boston University. Ms. Colerico has also been conducting research in the area of equatorial thermospheric dynamics using all-sky imaging observations made at Arequipa, Peru. An interesting feature that was observed was a region of bright 6300A airglow which moved poleward from this Southern Hemisphere station (north to south) through the field of view of the imager at approximately local midnight during equinox. She has written and submitted a paper on her observations to the Journal of Geophysical Research; this paper has been accepted for publication. The paper's title is: "Coordinated Measurements of F-region Dynamics Related to the Thermospheric Midnight Temperature Maximum" by M. Colerico, M. Mendillo, D. Nottingham, J. Baumgardner, J. Meriwether, J. Merick, B.W. Reinisch, J.L. Scali, C. Fesen, M.A. Biondi

E. FUTURE STUDY; INTERRELATIONSHIP OF HIGH LATITUDE AND EQUATORIAL IRREGULARITY DEVELOPMENT

It is expected that data sets similar to those cited will be used to study the effect of high latitude magnetic variations and high latitude phase fluctuations on the developments of plumes at the equator. It is the generation of neutral winds that is presently thought to be the dominating force in the day to day variations of scintillations. The study of magnetic storms effects on the generation or inhibition of equatorial plume structure for equatorial latitudes in all likelihood requires the use of the Dst measure (taken near the equator) and Kp or AE (taken at high latitudes).

Until the present it was difficult to correlate high latitude development of irregularities with those at equatorial latitudes. The data emanating from the GPS stations allows continuous observations of many sites will allow this. If this data set comes on line then forecasting may be available if we know the right parameters to put into the model. If so the study of the relationship of magnetic observations and high latitude development of irregularities would be of great assistance in forecasting scintillations at the equator; forecasting and warning will be of great importance particularly in the coming sunspot maximum.